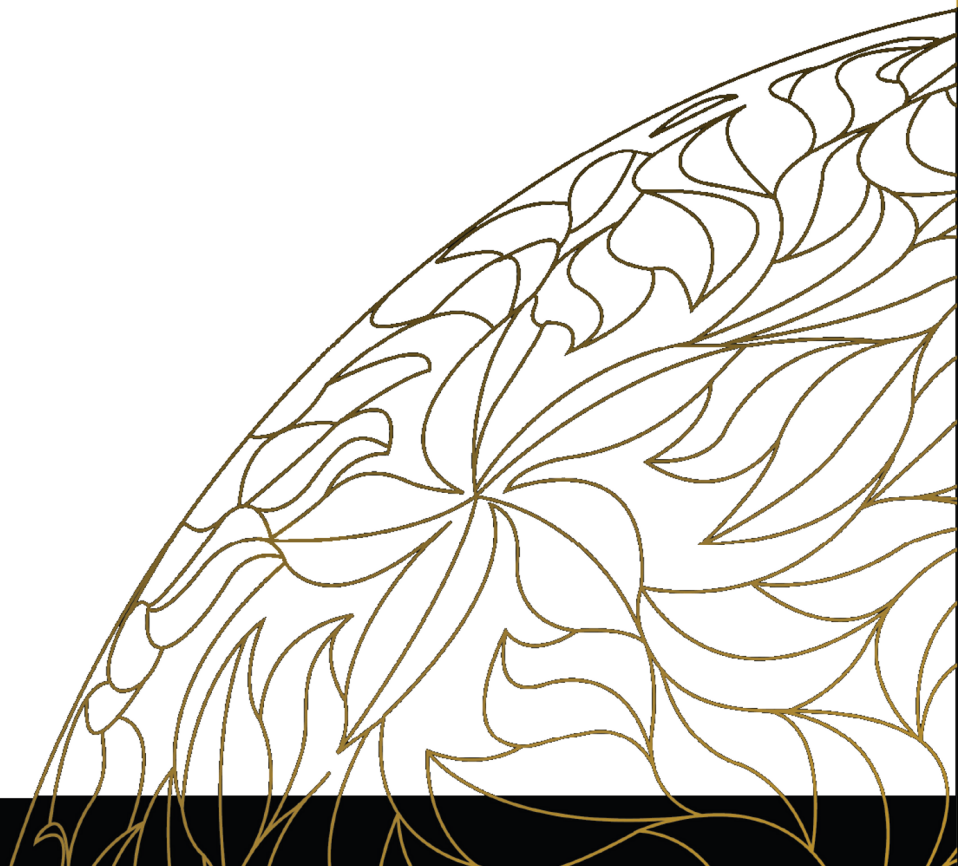


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Páipéar Taighde Teicniúil  
Research Technical Paper

*Was the Securities Markets Programme Effective in Stabilizing  
Irish Yields?*

David Doran, Peter Dunne, Allen Monks and Gerard O'Reilly



# Was the Securities Markets Programme Effective in Stabilizing Irish Sovereign Yields?\*

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## Abstract

We examine whether the ECB's Securities Markets Programme (SMP) was effective in reversing or stabilising adverse movements in Irish sovereign yields. Our initial analysis examines whether daily yield movements responded significantly to interventions. At the daily frequency we find no significant effects despite dealing with endogeneity and omitted variable bias. In contrast, making use of the exact timing of interventions and movements in high-frequency inter-dealer quotes, we find clear evidence that SMP stabilised yields on average from the moment of the initial intervention until the end of trading on intervention days. However, adverse pre-intervention movements were significant and these were seldom reversed by intervention effects.

**Keywords:** Keywords: Monetary policy; bond market interventions; Securities Markets Programme.

**Jel Codes:** E43, E44, E52, E53, G12, G14.

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## Non Technical Summary

The Securities Markets Programme (SMP) was launched by the Eurosystem in May 2010 and involved the intermittent purchases of sovereign bonds of several euro-area Member States with the objective of addressing a perceived malfunctioning of these markets and to restore a well-functioning transmission mechanism for monetary policy. In a relatively narrow sense, we examine the effectiveness of SMP by measuring how purchases of Irish sovereign bonds contributed to the stabilisation of Irish sovereign yields themselves. This is a prerequisite for broader effects such as the stabilisation of bank funding costs or the reduction of yields on substitutes. Such an evaluation is complicated by a number of methodological issues.

1. Endogeneity bias arises from the fact that interventions were usually triggered by adverse developments in yields. If one fails to control for this bias one may incorrectly conclude that intervention was ineffective or that it even led to yields rising. To address this endogeneity bias we use instrumental variable regression techniques. However, finding valid instruments is somewhat problematic. The use of intra-day data further clarifies the issue of endogeneity since one can exactly pinpoint how much yields have risen prior to intervention on a particular day.
2. There are many omitted information shocks during the period studied. Hence, yields may change for reasons other than intervention. We introduce control variables to mitigate some of this bias while the use of high-frequency intraday data further ameliorates such effects.
3. In terms of announcement effects we find, based on a detailed analysis of the first day of SMP (May 10th 2010), that about half of that day's price rise (yield fall) occurred in advance of actual SMP purchases. Hence, the announcement of the programme moved markets prior to actual purchases. We find that this initial observation has a distortionary influence on most regression results obtained for the full sample of intervention days.
4. Standard regression analysis, in which the yield change is regressed on the amount purchased under SMP, will find no relationship between the dependent and independent variables if yields are stabilized by interventions. We find evidence, particularly from intraday data, in support of this supposition and this may explain why extant studies have failed to find a relationship between daily amounts of SMP interventions and yield movements.

Overall, we find that regression analysis involving daily yield movements produces rather weak evidence that interventions had any effect on yield movements but this must be interpreted in light of the identification issue if yield movements were stabilized. We explore intraday price effects through a Cumulative Average Return analysis (CAR) at 5 minute intervals around each day's first SMP event. This makes it clear that interventions successfully halted a pronounced average decline in prices of bonds from the first intervention until the end of the intervention day.

We conclude that SMP was effective on the days of intervention but adverse movements often reoccurred the following day and new interventions were applied with such a lag that pre-intervention yield movements led to a cumulative drift. This may have been inconsistent with the programme's monetary policy objectives but it seems likely that it prevented some catastrophic movements of yields when market participants most feared an absence of liquidity on the buy-side of the market.

# 1 Introduction

The Governing Council of the ECB launched the Securities Markets Programme (SMP) on 10<sup>th</sup> May 2010. This action was taken to remedy a perceived malfunctioning of the securities markets and to restore an appropriate monetary policy transmission mechanism.<sup>1</sup> More specific objectives were not announced and it was unclear how aggressively the interventions would be implemented. If SMP reversed or stabilised intraday changes in yields on-average, then it is possible that it prevented some uncontrolled blowing-out of yields and resulted in an improved monetary transmission mechanism. This paper examines the impact of the policy at announcement and looks for evidence that the subsequent SMP interventions can be credited with reversing (or stabilizing) Irish yields.

Our analysis begins with an assessment of the reaction of daily yield movements to intervention amounts. We conduct this analysis controlling for endogeneity, announcement effects and omitted variable bias. Despite such controls we find no effect of interventions on daily yield changes. While this implies that interventions had no strong effects on yields it does not rule out stabilising effects. If policy makers followed a passive strategy of yield containment then it is possible that daily analysis would not reveal such effects. Indeed, yield increases prior to interventions may have been cancelled out by subsequent reversals. In essence, the daily analysis may not have controlled properly for endogeneity. To achieve a better resolution of these issues we supplement our daily analysis with an intra-day analysis which sheds further light on issue of endogeneity and reveals that interventions really did stop yield rises on intervention days.

Other authors have tried to assess the effectiveness of the SMP. Three such studies are summarized in Manganelli (2012). These identify a significant announcement effect but they conclude that SMP interventions had, at best, a very modest and very temporary downward effect on yields in targeted markets (see, Ghysels et al., 2012). Of particular relevance is the work of Trebesch and Zettelmeyer (2012) who focus on the impact of intervention in the Greek sovereign bond market. They identify the SMP purchases of Greek bonds using the fact that the ECB did not participate

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<sup>1</sup> In its communications on the SMP, the ECB has consistently placed an emphasis on the role of the programme in ensuring a proper transmission mechanism of monetary policy, with the ultimate goal of ensuring price stability. For example, in its press release of 10 May 2010, announcing the creation of the SMP, the ECB presented the programme as one of several measures “to address the severe tensions in certain market segments which are hampering the monetary policy transmission mechanism and thereby the effective conduct of monetary policy oriented towards price stability in the medium term”.

in the Greek debt exchange of March 2012 and can be assumed to have been the residual creditor. This allows for a cross-sectional study of the effects of SMP across 81 Greek sovereign bonds. They find a significantly greater drop in bond yields (after the start of SMP) for the bonds that were targeted most by SMP.

Our analysis also contributes to a growing literature that analyses the effects of bond purchase programmes undertaken by monetary authorities in recent years. But since the SMP intervention programme was very passively implemented, we have an opportunity to understand how markets reacted to a different kind of intervention policy. Two of the most relevant programmes studies recently are the US Federal Reserves' large-scale asset purchases (LSAPs) and the Bank of England's Quantitative Easing (QE) programme. Both of these programmes involved intervention in domestic sovereign bond markets, as well as some markets for private-sector securities. The objective of both has been to actively reduce longer-dated bond yields in the presence of a binding zero lower bound on the short-run policy rate, (intending to further ease the monetary policy stance).

These programmes required much more aggressive interventions to achieve their goals but despite the more aggressive approach, both time-series and event studies of Fed purchases of longer term treasury bonds suggest that bond yields were only temporarily reduced by the announcement of the programme (and actual interventions) and there is substantial variance across magnitudes and statistical significance of estimates (see Gagnon et al 2010a, 2010b and Hamilton & Wu, 2011).<sup>2</sup> In the case of QE in the UK, Joyce et al., (2011) find that yields on medium-and long-term gilts fell by under 100 basis points on foot of important quantitative easing announcements (less than in the case of SMP) but also do not find very convincing evidence of intervention effects beyond that.<sup>3</sup>

A daily event study in a similar vein to the one pursued in this paper is that of D'Amico & King (2010) for the US. They argue that examining the behaviour of individual securities delivers better results. They match purchases of particular instruments with developments in yields of those instruments using daily data. They also examine the extent to which purchases of bonds of differing maturity influences yields on other bonds. They find an average daily yield reduction of 3.5 basis

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<sup>2</sup>Prior to the crisis, Bernanke et al (2004) studied the response of yield curve during several episodes of treasury purchases of government securities.

<sup>3</sup>The exact mechanisms through which such purchases affect yields is also a matter of debate (see Andres et al., 2004, Vayanos and Vila, 2009, Krishnamurthy and Vissing-Jorgensenn 2011, and Christensen and Rudebusch, 2012), as is the magnitude of the impact on macroeconomic variables (see Chen et al., 2011, Chung et al., 2011, and Kapetanios et al., 2012).

points (with a cumulative effect of purchases of up to 50 basis points). The effect is greatest at the 5-year maturity and they argue the response of yields for individual purchases of securities is compatible with the view that there is a degree of segmentation in the treasury market. Daines et al. (2012) also find that the cumulative impact on gilt yields has varied significantly across the term structure, with maturities close-to, or in, the Bank of England's targeted range experiencing the largest declines in yield. In much of our analysis we follow the approach of D'Amico & King in examining effects for the individual targeted bonds.

Overall, our event-based analysis shows surprisingly large effects from a very passive intervention policy. Uniquely, we show that there is substantial evidence that intervention days produced stabilization of yields within the entire day after the first intervention and this stabilizing influence is quite constant over time. There is also strong evidence that the daily pre-intervention drift was very stable, with the exception of the weeks immediately surrounding Ireland's acceptance of bailout funds from the ECB, EU and IMF. This suggests that intervention was triggered by a particular yield change.

A secondary contribution of our analysis is how we circumvent the endogeneity issue. Most studies of intervention effects deal with endogeneity by using instrumental variable methods. However, such methods cannot be adequately tested and rely on appeals to the inherent validity of the instruments. Our detailed data on intervention events allows us to isolate post-intervention effects from pre-intervention price movements thereby avoiding the confounding of what triggered interventions from the effect of such interventions. This enables us to assess how important the endogeneity issue is. We find only marginal changes in the role of interventions even when this endogeneity problem is controlled for.

Section 2 concerns estimation and identification issues that motivate the methodologies used in our analysis. In section 3 we discuss the data used in the analysis. Section 4 presents the main regression results. Section 5 contains the results of a high-frequency intra-day analysis giving visual and statistical evidence that the Securities Markets Programme was successful in stabilizing yields. We conclude with a discussion of the policy implications and suggestions for future work.

## 2 Econometric Issues: Identification and Estimation

To motivate the daily and intraday analysis that we conduct below it is useful to outline some issues that are addressed by the techniques adopted. The daily regression analysis is appropriate to a situation where interventions actually move yields on average. The intraday analysis becomes appropriate when yields are merely stabilised by interventions. We conduct both types of analysis and this helps us to identify whether it is endogeneity or something else that drives the predominant regression result.

In a textbook version of intervention, the monetary authority would buy up existing bonds in the secondary market driving up their price and reducing yields. However, an econometrician trying to uncover and quantify the magnitude of such actions faces a number of difficulties. These can be grouped into the following categories;

1. omitted variable bias,
2. endogeneity,
3. announcement effects,
4. observational problem associated with full achievement of objectives.

Most studies of interventions try to address the first three of these problems. A typical approach would be to estimate equation (1) below in which the change in the yield on the sovereign bond  $\Delta i_t$  is a function of the size of the purchases under SMP with  $\alpha_2$ , the change in the yield due to intervention, predicted to have a negative sign.

$$\Delta i_t = \alpha_1 + \alpha_2 SMP_t + \alpha_3 x_t + \varepsilon_t \quad (1)$$

However, other variables simultaneously also affect yields. These variables are represented by the vector  $x_t$  and could drive yields in either direction. Ignoring such other variables gives rise to omitted variable bias which can result in biased estimates of  $\alpha_2$ . Ideally, one would like to control for such variables. However, bond markets are affected by numerous such variables and the econometrician is unlikely to be able to control for all of these.

The second issue facing the econometrician reflects the fact that interventions under SMP are not exogenous. In particular, interventions under SMP are likely to occur when bond yields are



rising. One could implicitly think of a reaction function which characterises such interventions as presented by equation (2).

$$SMP_t = \beta_1 + \beta_2 \Delta i_t + \beta_3 y_t + \eta_t \quad (2)$$

Interventions under SMP are positively related to changes in the yields with the coefficient  $\beta_2$  having a positive sign. The estimated coefficient  $\alpha_2$  will be biased because the shock term  $\varepsilon_t$  is correlated with the regressor SMP as a result of the response of the SMP to the interest rate as determined by parameter  $\beta_2$ . This is a classic case of simultaneous equation bias. Ideally one needs an instrument for the SMP which is exogenous to yield movements but still explains well SMP interventions. Choosing a suitable instrument is an inherently difficult exercise.

A third issue relates to the credibility of the intervention. If the markets viewed the purchases of government securities as perfectly credible it might be the case that the announcement of the intention to intervene would be enough to move yields. The interventions that coincide with the announcement would be an outlier and, if not treated separately, would bias regression results. Also, post-announcement interventions that confirm what was expected may lead to no significant effects. However, this assumes that the policy was immediately well-understood by markets and that there was knowledge about how policy would work even under unknown future circumstances. Most intervention policies are tested by markets simply because they do not know whether the policy maker is committed to initially announced objectives in all circumstances. This suggests that the full impact of an intervention policy is seldom felt in its entirety at announcement. The markets leave some room for reaffirmation through the actual interventions and this is sometimes measureable.

There is an additional observational issue, one that we find to be crucial for effective identification of intervention effects, when the objective of the programme was the halting (rather than reversal) of yield movements. In the absence of a target level for yields, it is possible that SMP interventions were simply designed to soak-up selling pressure on any given day in order to slow down the normal effects of such trading. In the market microstructure literature this would be called ‘passive’ intervention. Passive intervention requires the intervener to constantly advertise a bid price at which aggressive sellers can sell (the alternative approach is to go into the market aggressively buying what is on offer).<sup>4</sup>

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<sup>4</sup>In most financial markets there are two ways to buy or sell. One is to advertise a price (bid if buying

The SMP programme appears to have been passive. The outcome of a passive strategy would be a zero price change in the post-intervention period regardless of the amount bought by the intervener. The usual relationship between price movements and intervention quantity would therefore have been destroyed (in effect, no relationship would be found). This is particularly likely if the pre-intervention trigger was some particular amount of change in the dependent variable (which would be captured by a intercept parameter in the regressions analysis). Models such as equation (1) only work when the dependent variable changes in tandem with the independent variables.

Thus, the absence of a strong relationship between intervention size and yield movements sometimes found in intervention studies could be consistent with the hypothesis that intervention policy was passive and effective. We find that this is indeed a problem in our data and it is what motivates the intraday event-study discussed later. We find that the use of high frequency data can reveal yield stabilisation effects that are not detectable using regression techniques applied at a daily frequency.

### 3 Data

We make use of daily and intraday bond data in our analysis. The daily data consists of the yields at close of trading for benchmark Irish, German, Italian and Portuguese sovereign bonds.<sup>5</sup> The intraday data consists of bid and ask quoted prices (not yields) taken from the MTS interdealer bond trading platform (we use Greek data from MTS for the examination of the announcement effect on the first day of SMP but otherwise the focus is on Irish data). The bond data is used in conjunction with the interventions data. Daily intervention amounts are used in the case of our regression analysis. We were provided with the specific times and amounts of interventions so in our event analysis we utilize the time of the first intervention to separate price changes into pre- and post-event periods. Unfortunately, the exact dates and times (and amounts) of interventions are confidential so it is not possible to provide detailed descriptive statistics. However, it is well known and offer if selling) at which one is prepared to transact, while the other is to transact immediately against such advertised prices. Transacting immediately at advertised prices is deemed to be ‘aggressive’ because it involves incurring an immediate cost for trading equal to the bid-offer spread (see, Hasbrouck 1991a, 1991b). Sustained trading of this type is usually perceived to be ‘informed’ and it tends to drive price movements as buy-side quotes pull-back from their initial levels to reflect the information embedded in the trades.

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<sup>5</sup>In regressions we normally assess 8 different bonds separately and sometimes pooled (these are bonds with maturities of 1, 2, 3, 8, 9.5, 9.75, 10 and 14 years to maturity). In the event analysis we include long bonds as a group.

that interventions regularly represented a significant proportion of total trading activity in Irish bonds so we would expect to be able to determine the nature of the effects of SMP interventions using this detailed information.

The MTS trading platform is an important trading venue for primary dealers of euro area sovereign bonds. The euro-MTS electronic trading platform requires contributing dealers to provide firm quotes, on an almost continuous basis, for all benchmark bonds for which they are a designated primary dealer.<sup>6</sup> In the case of bonds issued by some euro-area countries primary dealers have strict conditions to satisfy in terms of liquidity provision (maximum bid-offer spreads and the requirement to be the provider of the best available quotes for a significant proportion of the day).

The requirements in force for primary dealers in Irish bonds became much less stringent soon after the acute interbank market crisis that followed Lehman's collapse in 2008. Primary dealer liquidity provision obligations no longer involve a maximum bid-offer spread. However, despite the limited nature of the conditions placed on dealers to provide a market, we find that changes in the Euro-MTS mid-quotes prevailing at the times of SMP events have a high correlation with SMP event-to-event price changes. On this basis we regard the percentage change in mid-quote (or the best ask) as indicative of changes in the underlying market valuation for time intervals in between SMP events. All MTS quotes are time stamped according to Central European Time (CET). The SMP transactions were also time stamped at CET.

While our high frequency interventions data is largely confidential we can discuss publically available daily (and later, intraday) yield data and its 1<sup>st</sup> difference. Figure 1 shows how Irish sovereign long-dated yields (and their 1<sup>st</sup> difference) fluctuated over the period of the SMP. Periods of particular volatility are apparent around the times of a rising risk of sovereign default either in Ireland or one of the other troubled periphery countries. The time series starts in March 2010 so it is possible to see the effects of the first day of SMP. This gave rise to the largest single-day decline in yield over the sample. Other large declines occur at significant macroeconomic events (e.g., the dates of credit rating downgrades), or at the re-starting of the programme after a long gap in activity, but what follows after most of these declines is a return to a steady upward trend. There

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<sup>6</sup> Dealers are designated by the issuer as a 'primary' if they are prepared to adhere to liquidity provision requirements in the secondary bond market. In return for this they normally receive privileged access to supply of bonds from the issuer for a few days following primary auctions and also some bond conversion facilities. In addition, they may obtain lead management of some future syndicated issuances. At the time of the study there were 16 primary dealers in the Irish bond market.

is an average daily climb in yields over the entire sample of almost 1 basis point. If the largest 3 daily declines are excluded the average daily rise in yields is over 1.5 basis points. Later we describe how the intraday price changes are also divided between declines in advance of the first intervention followed by a return to stability after the first intervention.

## 4 Regression Analysis of Market Reaction to SMP

In this section we discuss the results of regression analysis using daily yield changes as the dependent variable. The selection and use of instruments for endogeneity and controls for omitted variable bias is discussed. Later we show that similar results are found even if post-intervention price movements are used in a similar regression (thus excluding the change that triggered the intervention).

### 4.1 Daily Regression Analysis Results

Table 1 reports regression results for a baseline regression where the event window is based on days of the intervention with the dependent variable being the one-day change in the ten-year yield. In the first specification (1) total purchases of Irish bonds under SMP have a significant negative effect on the ten-year yield. However, once one controls for the start of SMP on May 10th and its restart in August 2011, this effect becomes insignificant. In regression specification (3) we control for developments in the German yield and the spread between Portuguese and Greek ten-year yield relative to Ireland.

As previously mentioned, intervention occurs when yields are rising, hence one should control for possible endogeneity of SMP purchases which could lead to biased estimates. Finding an instrument that is correlated with SMP purchases but not directly related to Irish yield spreads is a challenging task. A large number of instrument candidates were tried, but nearly all of them were not significantly correlated with SMP interventions.<sup>7</sup> One promising instrument that emerged was the volume (as recorded by Irish Stock Exchange) of Irish bonds traded excluding SMP purchases. This is correlated with SMP purchases and should not be directly related to movements in yields. In regression specification (4) to (6) volume is used as an instrument for SMP purchases. Using the rule of thumb proposed in Staiger and Stock (1998) and in Stock, Wright and Yogo(2002) this

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<sup>7</sup> Instruments assessed include the change in the euro exchange rate, the DAX, the VIX, interbank spread between unsecured and secured three month rate.

instrument doesn't suffer from a weak instrument problem.<sup>8</sup> Moreover, a Hausmann-style test of exogeneity fails to reject the null at the 5% level indicating that there is no significant difference in the coefficient estimates whether one relies on OLS or 2SLS potentially indicating that OLS is still appropriate. In all three regression specifications, where SMP purchases are instrumented, the coefficient associated with SMP have the wrong sign but are insignificant.

## 4.2 Security-by-Security Results

The next baseline regression seeks to assess the impact of purchases of an individual security on the one-day change in the yield of that respective security as follows.

$$\Delta i_t^j = \beta_0 + \beta_1 Own_t^j + \beta_3 x_t + \varepsilon_t \quad (3)$$

where  $\Delta i_t^j$  is the one-day change in the yield of security  $j$  at time  $t$ ,  $Own_t^j$  refers to the amount purchased of the  $j^{th}$  security while  $x_t$  refers to additional control variables. In Table 2, we report results of this regression specification for 8 individual securities. Impulse dummy variables are also included for the day the SMP programme was announced as well as on the days when it recommenced in August 2011. This dummy variable is highly significant in all regression specifications.

Purchases of only three of the eight securities give rise to a significant negative effect in terms of their respective yields. In Table 3, assessment is made of whether individual yields changed in response to total purchases under SMP across the maturity spectrum. For example, purchases of a ten-year bond are likely to impact yields on securities with different maturities. All but two of the individual bond yields decline significantly in response to total Irish SMP purchases. However, unsurprisingly the magnitude of the response is smaller when one examines total purchases and the results are not significant if one uses instrumental variables.<sup>9</sup>

Finally, we run a regression specification akin to that of D'Amico & King (2010)

$$\Delta i_t^j = \beta_0 + \beta_1 Own_t^j + \beta_2 Short_t + \beta_3 Long_t + \beta_4 X_t + \varepsilon_t \quad (4)$$

The rationale for such a specification is that purchases of bonds with a similar term to maturity are likely to be close substitutes, *ceteris paribus*, than bonds which have a greater maturity mismatch.

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<sup>8</sup> A rough rule of thumb is that an F test on the first stage regression in 2 stage least squares excluding the instrument should have a value greater than 10.

<sup>9</sup> The results for the instrumented regression are not reported here.

Hence, in theory one would expect such purchases to have a larger impact on the yield of a particular security than purchases of a security with a greater maturity differential. In this exercise, securities are grouped into two separate bundles: securities which have less than 5 years to maturity and securities with greater than 5 years and these are respectively labelled *Short* and *Long*.<sup>10</sup> As can be seen in Table 4, results are mixed. Purchases of long dated securities seem to be more important in impacting on short dated securities.

### 4.3 Discussion of Daily Analysis

In summary, a number of points are clear from analysis of the daily results. There isn't strong evidence that purchases of securities under SMP had a significant negative effect on yields once one controls for announcement effects. This might be considered as evidence that interventions were not effective. Alternatively, it could be that the endogeneity issue confounds the results. Finding suitable instruments proved difficult and standard exogeneity tests really only indicate whether there is a statistical significant difference between the OLS estimator as compared to the two stage least squares estimator. In addition, total purchases of securities seem more important than purchases of individual securities in terms of influencing yields on any particular segment of the yield curve. This is probably not surprising given the small number of different securities trading. Hence, we don't appear to find segmented or differential responses across yields depending on proximity of the maturity purchases.

### 4.4 Regressions using intraday price changes before and after SMP

It might be expected that a regression analysis that employs the intraday post-intervention price change as the dependent variable and daily SMP quantity as the main explanatory variable would fare better than regressions using the full day's change. However, while this alternative dependent variable should circumvent part of the endogeneity problem arising from SMP activity being triggered by price falls, unfortunately we find that it doesn't avoid the observational issues associated with a successful passive strategy of interventions that halt price movements.

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<sup>10</sup> Note in each regression we remove purchases of actual yield of interest as they are included in *Own*.

## 4.5 Bond-Specific and Pooled Regressions

Table 5 Panel A displays the regression results for the 8 bond-specific regressions in which the dependent variable is the post-intervention % price change and the own-bond intervention quantity is the main independent variable. Only the days of own-interventions are included. Additional regressors are included in Panel B for intervention at the short end of the market and interventions in the longer dated bonds. Parameter estimates that are statistically different from zero at the 10% level of significance or better are in bold. The first day and the day of the re-start of SMP in 2011 is omitted from the sample in all cases and the outlier on 25<sup>th</sup> Nov 2011 is also dropped.

In the case of Panel A we see that there are positive coefficients on the intervention quantity in all cases beyond the two shortest maturity bonds. However, there is only notable significance of the intervention variable in the cases of the first 9-year bond and the 14-year bond. In all cases the goodness of fit of the regressions is very low. In the case of Panel B there is a significant improvement in goodness of fit but there is more confusion about where the significant effects are located. Significance has shifted to the short-end but the variable most responsible for significance is long-bond interventions. The main point to take from these results is the lack of significance of the SMP size effect. There is little improvement over the results obtained from the daily yield regressions.

In Table 6 the analysis is extended so that price changes in individual bonds can react to all interventions. Thus all intervention days are included and the independent variable is the same in each case (total SMP interventions across all bonds). This allows cross-bond restrictions to be tested and for a pooled regression. Panel A of Table 6 provides the results of bond-specific and pooled regressions where the dependent variable is the post-intervention percentage price change. Panel B contains results for the same basic relation except that the full-day percentage price change is used as the dependent variable. This allows a test of whether the full-day variable is capable of delivering useful results despite the fact that there is an endogeneity problem. This has implications for the likelihood that the regression using the daily yield change as the dependent variable suffers significantly from the same endogeneity problem.

The results in Panel A of Table 6 are consistent with positive price effects from SMP at the longer end of the maturity basket (any significant coefficients are positive and the two negative coefficients are have large standard errors). Since the pooled regression does not have a significant slope coefficient we can conclude that the effects of SMP are not the same across the yield curve.

The 3y, 9y(1), 9y(2) and 10y regressions display slope coefficients that are similar in magnitude and either significant at the 10% level or close to significant at this level of confidence.

The results in Panel B of Table 6 are not very different (although coefficients are less statistically significant) from those of Panel A despite the fact that the full-day price change is used as the dependent variable. This shows that the daily regressions are not severely affected by the endogeneity problem. It seems likely that most of the pre-intervention effect is captured by the constant which is usually negative when the slope coefficient is close to significant. In Panel B we include the significance level of a test of the restriction that the slope coefficient is the same in each of the two regressions involving the same bond. In the case of the first 9-year bond the hypothesis that the slope coefficient when the full-day price change is used as the dependent variable cannot be rejected as equal to that when the post-intervention price change is used. In the cases of the 3-year bond the same hypothesis could not be rejected at the 5% level of confidence. Similarly in the case of the second 9-year bond the hypothesis is only marginally rejected at the 5% level.

Overall, there is relatively weak regression evidence that the effects of SMP are statistically significant and they are never large in magnitude. However, this is what would be expected if the policy objective was to halt declines rather than reverse them. The coefficient estimate on SMP in the pooled regression indicates that the percentage price change per billion euro of SMP is about one-third of one percentage point. This is not large given the usual daily volumes traded in the Irish bond market around this time (available from the Irish Stock Exchange). Still, the small magnitude of the effect should not be viewed as an indication of a failure to meet the objective.

## 5 Intraday Event Analysis

The effectiveness of SMP interventions can be assessed at a higher frequency by examining the changes in quotes on the MTS interdealer trading platform in time intervals before and after the initiation of interventions.<sup>11</sup> We report below the results for such an analysis for all interventions

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<sup>11</sup> It should be noted that traded volumes in Irish Bonds transacted on the MTS platform are very low and that dealer commitments are significantly less onerous than usually expected from primary dealers (there is no maximum spread applied). However, particularly for the longer dated bonds, the mid-point between the best bid and offer quotes does seem to be a reasonable indicator of the market price when compared with SMP transactions prices (SMP transaction prices tend to be above the best prevailing ask quote). The only alternative sources of pricing are Bloomberg Bond Trader and the TradeWeb dealer-to-customer



in the Irish bond market since the beginning of SMP until the end of 2011 and also for a sub-sample around the time of the Irish bailout (Oct-to-Dec 2010). The results indicate significant price declines in advance of interventions and strong evidence of a stemming of declines (or a reversal of the pre-intervention decline on big intervention days). The stability of yields on-average in the post-intervention periods explains why the regression analysis failed to give strong results.

## 5.1 Intraday Methodology

The event analysis involves the calculation of the average cumulative percentage change in quoted prices at 5 minute intervals during the 3 hour period before and after the initial intervention each day for a number of Irish bonds. The advantage of averaging the percentage changes and then accumulating, rather than just averaging price levels at specific intervals, is that the price levels can differ significantly across bonds and events (the sample of bonds is not the same for all the events). The methodology adopted here is analogous to a standard “CAAR analysis” (Cumulative Average Abnormal Returns analysis) commonly used in the study of equity market events except that we do not need the usual normalization. The abnormal return is usually found by subtracting an ‘expected percentage change’ based on an asset pricing model but we do not require this step at such a high frequency so a more appropriate acronym is “CAR”. Controlling for other expected price effects may be valid but it is not likely to be a source of major distortions at 5 minute intervals. Also, when events are taken from many different time periods confounding effects will mostly be idiosyncratic across events and these will average out at zero.

Our initial analysis considers the impact of SMP interventions regardless of its size and assumes that the time of the first intervention in each bond is the start of the post-event window. There are issues regarding what can be referred to as the beginning of an event on any given day. It could be the start of SMP purchases regardless of the bond in which interventions occurred. Alternatively, it could be bond-specific in which case there are often numerous start times in any given day. If there are cross-effects from intervention in one bond on another then it makes sense to calculate the effects from the start of interventions on each day regardless of the bond. This is what we do below.<sup>12</sup> Moreover, the daily results seem to suggest that aggregate purchases are more important than individual bond purchases. If interventions are effective they should slow-down, halt or reverse platform but the latter operates on a request-for-quote basis and the quote information is not made public. Bloomberg Bond Trader quotes were not available to us.

<sup>12</sup> Of course, it is also possible that there are cross-effects running from SMP interventions in other

any perceptible downward trend in the accumulated changes that occurred in the pre-intervention intervals. This can be assessed visually from the plot of the cumulative average changes but it can also be assessed with statistical confidence using ordinary t-tests for differences in means and, where appropriate, we state the result of these tests.

## 5.2 The Announcement Effect

Before preceding to the event analysis we examine the first day of SMP because this was a large outlier and it is either dummied-for or omitted from much of our regression and event analysis. This also allows us to examine whether it is possible to draw a distinction between the announcement effect and the actual intervention effect. The first day of SMP was 10<sup>th</sup> May 2010. The programme was announced at 03:00 before markets opened. The announcement effect in the case of Irish bonds is difficult to analyse using high frequency intraday data because there are no MTS quotes until about 12:50 on that day. EuroMTS Ltd state that dealers were not prepared to provide firm quotes in the inter-dealer market until bond prices had fully responded to the SMP announcement and until some SMP activity had taken place in the OTC market. In the absence of reliable Irish quote data we instead assess what occurred in the Greek bond market on the first day. Figure 2 shows the time series at 5 minute frequency of average bid and ask prices for the most liquid Greek bonds around the announcement.<sup>13</sup>

The price reaction to the announcement is very clear. An immediate reaction witnessed is in the form of a widening of the spread. The earliest quoted spread is very wide and this reflects large uncertainty and risk aversion with dealers providing quotes in the interdealer market that are not likely to be attractive to either buyer or seller. Once the initial uncertainty declines both quotes rise dramatically relative to the previous day's close. The first Greek SMP intervention was at 09:06. Both bid and ask quotes had risen substantially before this time but there was a large additional effect following intervention. The high point of the reaction was at about 9:30 and after this we observe a slight decline until lunchtime. The eventual effect on the day was a rise in the bid quote

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country-specific bond markets. In this case the start of SMP would more appropriately be the start of SMP in any part of the Euro-Area bond market.

However, since there was a high degree of coordination in interventions we assume that using the time of the first intervention on the Irish bond market is a reasonable approximation to the actual start time anywhere.

<sup>13</sup>The situation for Portuguese bonds is similar although the range is not as large as in the Greek case.

from 60 to 75 and a rise in the ask quote from 71 to 86. About half of the day's rise had occurred before the first SMP trade and this can be attributed to the announcement effect.

### 5.3 Cumulative Average Returns Analysis

We begin with an analysis of interventions in all bonds with more than 7.5 years to maturity for all of the active SMP days (except the first day of interventions in May 2010). Figure 3 displays the cumulative average return (CAR) around the SMP interventions for these long bonds.<sup>14</sup> Two versions of the CAR results are presented based respectively on the percentage change in the mid-price and percentage change in the offer-price. In the case of the former, we observe a decline of less than 10 basis points on average in the three hours prior to SMP intervention while afterwards there is a flattening of the cumulative returns series. The cumulative returns (based on offer-prices) display a more acute decline before SMP interventions but also flattens-out afterwards.

Thus, the effect of SMP intervention evaluated for this selection of bonds seems to indicate that SMP halts the decline in bond prices on average. The effect seems to be similar within sub-samples. This is shown in Figure 4 where the CAR for the first few months of the SMP program is plotted alongside the CAR for the period around the time of the Irish bailout. There is very little difference in the two episodes and we conclude from this that the intraday effects from interventions appear structurally stable. There were an insufficient number of events in the last episode to generate worthwhile statistics for that case.

If one assumes that prices had continued their trend downwards in the absence of interventions, then an average daily percentage price decline of roughly 20 bps would have happened (or a cumulative percentage decline over 111 days of roughly 20%). Of course, this is not a satisfactory counterfactual scenario since it does not take into account the effect that previous accumulated changes would have in dictating the following days' outcomes. However, the CAR analysis does suggest that there were smoothing effects of the SMP interventions.

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<sup>14</sup> We chose to keep all of the initial daily interventions in the sample even if a full pre- or post-event history of price changes was not available (i.e., we include early and late interventions even where we do not have a full 3 hour window in the pre- or post-event period). The number of observations in each interval is therefore variable and this has a small effect on the standard error bounds.

## 5.4 The impact of SMP interventions on ‘small’ and ‘big’ SMP days

We found that most individual SMP interventions were close to the modal size of interventions. The proportion of transactions between zero and the modal nominal traded quantity is almost 23% leaving only 17% of SMP transactions greater than the modal size. We also were able to identify SMP days in which the amount of SMP intervention exceeded 150 million euro of nominal value. We examine the difference in price impact for these two groups of days to see whether larger than normal intervention days had a greater cumulative price change. The CAR for small and big SMP intervention days is shown in Figure 5.

To avoid clutter we have not included the standard error bounds but we can report that there is a statistically significant difference in all the post-event impacts for the large and small SMP intervention days after 50 minutes. Specifically, the t-test for differences in means at 50 minutes after the event (under the assumption of differences in variances) has a p-value of 0.325 but at 60 minutes after the event the p-value for the t-test of differences in means is 0.0065 indicating decisive rejection of the hypothesis of equal means. The largest p-value thereafter is 0.0963 for 1 hour 20 minutes after the first intervention but most of the other p-values from 50 minutes on are close to the 1% level.

It is clearly the case that big intervention days involve significantly greater eventual effects of SMP. In fact, we can see that the pre-intervention price drift is almost fully reversed by SMP on the big intervention days. A t-test for difference in the mean level of the index at 2 hours and 55 minutes before the intervention and that at 2 hours and 55 minutes after the intervention is 0.239 (with degrees of freedom 109). It is therefore not possible to reject the hypothesis that pre-intervention price decline was fully reversed on big intervention days.

## 5.5 Lessons from the intraday CAR analysis

One important insight that an intraday CAR analysis provides is that one can ascertain the extent of the decline in price (rise in yields) that occurred prior to the start of SMP interventions. This highlights the difficulties of any analysis that would rely entirely on daily yield (or price) changes and indicates the magnitude of the endogeneity issue. The intraday reaction in the case of large interventions illustrates this point. For large interventions, the change in price from the beginning to the end of the day was essentially zero. An analysis at a daily frequency would reveal no relation

between SMP and daily price change in this case.

The intraday analysis can shed some light on the trigger for interventions. It was stated earlier that a trigger for intervention on any given day was a rise in yields. While this was not a hard-and-fast rule we can assess the average rise in yield (or price decline) from the time series of the pre-intervention percentage price decline and this is shown in Figure 6. This reveals that there was quite a variable pre-intervention decline over time. We note that the cumulative declines over events days shown in Figure 7 reveal a relatively smooth trend that can be attributed to these, almost daily, pre-event declines. Figure 7 also shows the time series of cumulative percentage price movements in the post-intervention part of intervention days. This shows the familiar flattening of the yield movements after interventions for most intervention days.

While there is clear evidence of structural stability in this decline over time there are some instances where prices show a pronounced cumulative rise and others where the decline is more or less pronounced than the average. This could be consistent with variation in the degree of aggressiveness used in implementing interventions. There is a decline in the cumulative post-intervention percentage price change for a week or two preceding the Irish bailout in October/November 2010 and it is possible that, in the minds of market participants, this was a period when commitment to SMP intervention policy was wavering. Of course it is also possible that fundamental events were simply too big to be adequately counteracted by a passive intervention approach. Similarly, either a more aggressive period of interventions occurs just after the Irish bailout when post-intervention prices are driven up (and yields are driven down) or this just reflects positive sentiment as a result of accepting bailout funding. It is nevertheless interesting that SMP was actively facilitating the improvement in yields around this time.

## 6 Conclusions

The analysis above provides evidence on the effectiveness of a very unique intervention policy. We have shown that the *go-to* regression methods often used in assessing intervention effectiveness are inadequate when the intervention policy is designed merely to stabilise yields. Regression analysis is shown not to produce strong results even if endogeneity issues are completely absent. We make stringent efforts to surmount these inadequacies. As a consequence, we find that SMP effects are very visible when they are analysed using an intraday event-based methodology. Overall, we find

substantial announcement effects and strong evidence that SMP interventions, on-average, halted declines in bond prices (rises in yields). The policy was therefore effective if we interpret its main objective as passive containment. While yields did drift over time (and on active intervention days) there was a very stable pre-intervention drift.

The strong announcement effects that we and others have found, seem puzzling given the size of the fundamental headwinds that were affecting Irish sovereign yields over the sample period and the eventual passivity with which interventions were undertaken. It seems probable that markets were expecting something more aggressive at the start of the programme and that this was slowly undermined over time. How this was facilitated in practice is now visible from the cumulative pre-intervention drift that was permitted on each intervention day. It also becomes clear from our analysis how intervention effects eased in advance of Ireland's acceptance of funding from the EU and IMF.

Our findings confirm that interventions matter even when they are undertaken with some reluctance. While the effects may appear to be minor and temporary, it is possible that they had deeper second-round impacts that we cannot validate. For example, the stabilization of yields may have reduced the expected risks associated with holding Irish bonds. Likewise, the liquidity generated by interventions on the buy side of the market may have provided the comfort of an expected exit strategy for investors if needed. These reduced risks for investors may have prevented a more acute crisis (and rise in yields) and could have contributed to expectations of stable market conditions. These expected conditions may have helped to depress yields but there is no obvious way to adequately measure the size of these contributions.

There are some policy lessons from the SMP experience. Firstly, we find that regular passive interventions can stabilise yields even in the context of volatile fundamentals. A positive attribute of the passive intervention policy is that it can generate stability without trying to *buck* the long term trend of the market. This keeps the policy effective for longer. We find very little diminution in the effectiveness of interventions over time as might have been expected given that it became obvious that SMP holdings would not be available for debt-swap or restructuring. This was probably also helped by the fact that information about the amounts invested by the intervener remained largely unconfirmed (suggesting that this was wise from a policy perspective).

The positive (stabilising and liquidity enhancing) effects are all the more interesting given the number of negative developments that were counteracting them. Both bank and sovereign debt

dynamics, and their interaction, were becoming ever-more pernicious contributors to instability over this period. There was also fear among market participants that the progressive building of a large intervention position would have become too big a risk for the intervener and could have weakened commitment to the intervention programme. The programme itself was publicly criticised by one of the ECBs Governing Council members. There was also increasing awareness that SMP holdings would not be included in any debt-swap or restructuring (which would have increased the potential expected losses on a diminishing number of other holders) and at some point this would have made periphery sovereign bonds even less attractive. Thus, in the context of its objectives and the underlying volatility in fundamental forces, SMP was remarkably effective in reducing yields when it was announced and in stabilizing yields for prolonged periods subsequently. This should give encouragement to policy makers planning interventions that are backed-up by policy initiatives that *ex ante* improve fundamentals.

While, the intraday analysis above reveals much more than could be garnered from a typical regression approach, the application of other regression techniques may improve further on the event analysis. In particular, it would be interesting and useful to be able to ascertain whether the provision of an exit for investors through interventions was a driving force of yield dynamics during the SMP period. This could be analysed by employing a more detailed multi-equation analysis of the duration between interventions, the amount at each intervention and the impact of interventions on price. Such an analysis could uncover whether markets reacted to unexpected delays in intervention or to surprises in the amount of intervention undertaken. We leave this potentially worthwhile avenue for future work.

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Table 1: Baseline Daily Yield Change Regression: 10 year benchmark yield.

	(1)	(2)	(3)	(4) <sup>d</sup>	(5) <sup>d</sup>	(6) <sup>d</sup>
Constant	0.05 (1.95)	0.03 (1.54)	0.06 (4.1)	0.01 (0.15)	0.02 (0.81)	0.03 (1.14)
<i>SMP</i> <sup>a</sup>	-0.26 (-2.35)	-0.04 (-1.10)	-0.13 (-2.93)	0.02 (0.19)	0.02 (0.14)	0.04 (0.24)
<i>DUM1</i> <sup>b</sup>		-1.16 (-16.35)	-1.95 (-6.41)		-1.27 (-5.99)	-2.13 (-5.64)
<i>DUM2</i> <sup>b</sup>		-0.3 (-14.24)	0.01 (0.09)		-0.31 (-13.42)	-0.02 (-0.29)
<i>DUM3</i> <sup>b</sup>		-0.44 (-21.08)	-0.29 (-5.29)		-0.44 (-21.42)	-0.31 (-5.59)
<i>GE3</i> <sup>c</sup>			-0.19 (-0.67)			-0.16 (-0.57)
<i>PT3</i> <sup>c</sup>			-0.61 (-3.27)			-0.62 (-3.17)
<i>GR</i> <sup>c</sup>			-0.2 (-1.85)			-0.16 (-1.49)
$\bar{R}^2$	0.11	0.31	0.66	0.00	0.31	0.62
Hausmann Wu				3.17 [0.08]	0.21 [0.64]	3.24 [0.07]
1st Stage F-Test				60.83 [0.00]	93.54 [0.00]	108.68 [0.00]

**Notes:** The dependent variable is the one-day change in the bond yield (source: DataStream). Robust t-statistics are reported in brackets. The sample includes only intervention days. (a) *SMP* denotes purchases of Irish securities. (b) *DUM1*, *DUM2* and *DUM3* are impulse dummies associated with 10<sup>th</sup> of May 2010 and 4<sup>th</sup> & 5<sup>th</sup> of August 2011. (c) *GE*, *PT* and *GR* refers to the 1-day changes in; the German 10 year yield, the spread between the Portuguese and Irish 10 year yields and the spread between the Greek and Irish 10 year yields. (d) The instrumental variable used in the final 3 columns is the daily volume of Irish bonds purchased excluding *SMP* purchases. (e) Durbin-Hausmann-Wu test of exogeneity. Terms in square brackets are probability of rejecting the null. (f) F-test assessing strength of instrument. An F-statistic > 10 suggests instruments are not weak. Square brackets refer to p value of excluding volume from 1<sup>st</sup> stage regression.  $\bar{R}^2$  is the adjusted R-Squared statistic.

Table 2: Effects of own-interventions on daily yield change of individual bonds.

Maturity	1y	2y	3y	8y	9y1	9y2	10y	14y
Constant	0.05 (1.49)	0.04 (1.27)	0.05 (1.29)	0.05 (2.15)	0.04 (2.25)	0.05 (2.32)	0.04 (2.37)	0.03 (1.86)
<i>DUM1</i> <sup>a</sup>	-2.09 (-15.32)	-1.2 (-4.36)	-1.26 (-14.95)	-0.76 (-8.18)	-0.96 (-12.15)	-0.58 (-4.06)	-0.95 (-12.46)	-0.54 (-29.42)
<i>DUM2</i> <sup>a</sup>	-0.39 (-12.85)	-0.18 (-2.08)	-0.31 (-8.50)	-0.25 (-11.38)	-0.31 (-12.01)	-0.22 (-5.53)	-0.32 (-17.04)	-0.25 (-13.57)
<i>DUM3</i> <sup>a</sup>	-0.46 (-14.10)	-0.82 (-15.04)	-1.87 (-55.61)	-0.33 (-15.17)	-0.3 (-12.30)	-0.26 (-12.35)	-0.4 (-21.12)	-0.31 (-19.33)
<i>Own</i> <sup>b</sup>	-0.2 (-0.23)	-2.53 (-1.49)	-0.34 (-0.77)	-0.86 (-1.96)	-0.32 (-0.88)	-1.4 (-2.29)	-0.74 (-1.97)	-0.2 (-0.38)
$\bar{R}^2$	0.31	0.28	0.35	0.21	0.28	0.22	0.31	0.15

**Notes:** The dependent variable is the one-day change in the bond yield (source: DataStream). Heteroscedasticity and serial correlation robust t-statistics are reported in brackets. The sample includes only days when there was intervention in Irish bonds. (a) *DUM1*, *DUM2* and *DUM3* are impulse dummies associated with 10<sup>th</sup> of May 2010 and 4<sup>th</sup> & 5<sup>th</sup> of August 2011. (b) *Own* denotes total SMP purchases of the security itself.  $\bar{R}^2$  is the adjusted R-Squared statistic.

Table 3: Effects of total bond purchases on individual daily bond yields.

Maturity	1y	2y	3y	8y	9y1	9y2	10y	14y
Constant	0.07 (2.15)	0.04 (1.12)	0.06 (1.69)	0.05 (2.3)	0.04 (2.05)	0.05 (2.16)	0.05 (2.36)	0.04 (2.3)
<i>DUM1</i> <sup>a</sup>	-1.83 (-20.36)	-1.36 (-11.69)	-1.02 (-8.96)	-0.77 (-10.41)	-0.92 (-13.94)	-0.71 (-9.44)	-0.96 (-15.62)	-0.46 (-8.44)
<i>DUM2</i> <sup>a</sup>	-0.37 (-13.36)	-0.26 (-7.44)	-0.3 (-8.84)	-0.22 (-9.57)	-0.31 (-14.49)	-0.27 (-12.13)	-0.3 (-15.09)	-0.24 (-13.87)
<i>DUM3</i> <sup>a</sup>	-0.46 (-16.43)	-0.86 (-25.22)	-1.86 (-56.49)	-0.32 (-14.25)	-0.31 (-14.78)	-0.25 (-11.44)	-0.39 (-20.14)	-0.31 (-18.41)
<i>TOTAL</i> <sup>b</sup>	-0.17 (-3.13)	-0.14 (-2.04)	-0.17 (-2.65)	-0.1 (-2.47)	-0.06 (-1.74)	-0.11 (-2.67)	-0.08 (-2.31)	-0.04 (-1.44)
$\bar{R}^2$	0.32	0.28	0.36	0.21	0.28	0.21	0.3	0.15

**Notes:** The dependent variable is the one-day change in the bond yield taken from DataStream. Heteroscedasticity and serial correlation robust t-statistics are reported in brackets. The sample period includes only days when there was intervention in Irish bonds. (a) *DUM1*, *DUM2* and *DUM3* are impulse dummies associated with 10<sup>th</sup> of May 2010 and 4<sup>th</sup> & 5<sup>th</sup> of August 2011. (b) *Total* denotes total purchases of all Irish bonds.  $\bar{R}^2$  is the adjusted R-Squared statistic.

Table 4: Effects of own, short- and long-dated bond purchases on individual bond yields.

Maturity	1y	2y	3y	8y	9y1	9y2	10y	14y
Constant	0.08 (2.36)	0.05 (1.33)	0.06 (1.82)	0.05 (2.35)	0.04 (1.99)	0.04 (1.97)	0.05 (2.35)	0.04 (2.44)
<i>DUM1</i> <sup>a</sup>	-1.71 (-13.53)	-0.95 (-3.60)	-0.89 (-5.74)	-0.71 (-7.45)	-0.82 (-9.38)	-0.57 (-3.69)	-0.92 (-12.37)	-0.35 (-2.57)
<i>DUM2</i> <sup>a</sup>	-0.33 (-8.45)	-0.16 (-1.77)	-0.30 (-9.41)	-0.24 (-9.83)	-0.33 (-14.21)	-0.23 (-3.46)	-0.32 (-12.14)	-0.24 (-10.81)
<i>DUM3</i> <sup>a</sup>	-0.49 (-15.94)	-0.83 (-14.90)	-1.88 (-62.51)	-0.33 (-16.00)	-0.33 (-13.40)	-0.27 (-12.73)	-0.4 (-21.75)	-0.32 (-21.40)
<i>Own</i> <sup>b</sup>	1.55 (2.13)	-2.34 (-1.13)	0.55 (1.24)	-0.59 (-1.62)	0.13 (0.21)	-1.7 (-1.23)	-0.6 (-0.93)	0.42 (0.54)
<i>Short</i> <sup>c</sup>	0.06 (0.17)	0.67 (1.61)	0.41 (0.73)	0.46 (1.4)	0.37 (1.28)	0.42 (1.46)	0.28 (1.29)	0.32 (1.58)
<i>Long</i> <sup>d</sup>	-0.83 (-3.52)	-0.62 (-2.16)	-0.73 (-2.53)	-0.55 (-1.75)	-0.67 (-2.13)	-0.26 (-0.95)	-0.31 (-1.17)	-0.42 (-1.79)
$\bar{R}^2$	0.33	0.29	0.36	0.22	0.3	0.22	0.3	0.17

**Notes:** The dependent variable is the one-day change in the bond yield taken from DataStream. Heteroscedasticity and serial correlation robust t-statistics are reported in brackets. The sample period includes only days when there was intervention in Irish bonds. (a) DUM1, DUM2 and DUM3 are impulse dummies associated with 10<sup>th</sup> of May 2010 and 4<sup>th</sup> & 5<sup>th</sup> of August 2011. (b) *Own* denotes total SMP purchases of the security itself. (c) *Short* denotes total purchases of bonds with less than five years to maturity. (d) *Long* denotes purchases of bonds with greater than five years to maturity.  $\bar{R}^2$  is the adjusted R-Squared statistic.

Table 5: Effects of own-interventions when only own-intervention days are included.

Panel A								
Maturity	1y	2y	3y	8y	9y1	9y2	10y	14y
Obs	31	31	65	40	76	41	33	25
Cons	0.002 (0.028)	0.911 (0.819)	0.108 (0.576)	0.413 (1.165)	-0.081 (-0.428)	0.24 (0.802)	0.301 (0.777)	-0.257 (-1.444)
Own	-1.106 (-0.86)	-4.843 (-0.355)	0.24 (0.192)	1.485 (0.411)	<b>4.527</b> <b>(1.812)</b>	3.236 (0.769)	2.617 (0.752)	<b>9.532</b> <b>(2.844)</b>
$\bar{R}^2$	0.018	0.001	0.000	0.001	0.019	0.006	0.006	<b>0.157</b>
Panel B								
Cons	-0.000 (-0.402)	0.007 (0.633)	0.003 (0.999)	0.004 (1.002)	-0.008 (-1.249)	0.002 (0.569)	0.001 (0.254)	<b>-0.005</b> <b>(-2.231)</b>
Own	-0.020 (-0.717)	0.054 (0.665)	-0.018 (-0.327)	0.012 (0.480)	0.105 (1.207)	0.121 (1.463)	-0.000 (-0.001)	0.171 (2.078)
Short Q	-0.006 (-0.753)	-0.020 (-0.709)	0.008 (0.244)	0.003 (0.205)	-0.064 (-1.295)	-0.010 (-0.72)	-0.006 (-0.229)	-0.011 (-0.575)
Long Q	<b>0.017</b> <b>(3.340)</b>	0.005 (0.337)	0.001 (0.069)	0.003 (0.177)	<b>0.074</b> <b>(1.687)</b>	-0.000 (-0.01)	0.016 (0.799)	0.001 (0.026)
$\bar{R}^2$	<b>0.293</b>	0.003	0.002	0.009	0.042	0.077	0.019	<b>0.194</b>

**Notes:** In Panel A each regression includes a constant and the own SMP intervention (EUR Bln.). Additional regressors are included in Panel B to allow for different effects when interventions are at the short- and long-end of the market. Heteroscedasticity and serial correlation robust t-statistics are reported in brackets. Parameter estimates that are statistically different from zero at the 10% level of significance or better are in bold.  $\bar{R}^2$  is the adjusted R-Squared statistic. The first day and the re-start of SMP is omitted from the sample in all cases and the outlier on 25<sup>th</sup> Nov 2011 is also dropped.

Table 6: Effects of total SMP interventions: post-intervention % price change compared with full-day % price change.

Panel A									
Maturity	Pooled	1y	2y	3y	8y	9y1	9y2	10y	14y
Obs	101	98	98	98	98	98	98	98	98
Cons	0.074 (0.786)	0.114 (0.643)	0.623 (1.271)	-0.005 (-0.05)	0.386 (1.614)	0.111 (0.717)	0.103 (0.686)	-0.055 (-0.31)	-0.411 (-0.94)
Total	0.013 (0.0617)	-0.164 (-0.61)	1.032 (0.781)	<b>0.465</b> <b>(2.221)</b>	0.023 (0.058)	0.535 (1.432)	0.371 (1.375)	<b>0.624</b> <b>(1.805)</b>	-1.203 (-0.56)
$\bar{R}^2$	0.005	0.001	0.002	0.014	0.000	0.009	0.005	0.010	0.002
Panel B									
Cons	-0.051 (-0.442)	0.18 (0.999)	0.569 (1.118)	-0.118 (-0.96)	0.128 (0.482)	-0.292 (-1.41)	0.008 (0.043)	<b>-0.521</b> <b>(-2.315)</b>	-0.671 (-1.449)
Total	0.825 (1.547)	0.306 (0.702)	0.771 (0.61)	0.255 (1.232)	0.047 (0.095)	0.455 (1.151)	0.418 (0.981)	<b>0.908</b> <b>(1.737)</b>	-1.245 (-0.561)
$\bar{R}^2$	0.012	0.002	0.001	0.004	0.000	0.004	0.004	0.014	0.002
Signif		0.001	0.008	0.055	0.016	<b>0.133</b>	0.048	0.000	0.020

**Notes:** In Panel A the dependent variable is the post-intervention % price change and each regression includes a constant and the total SMP intervention (EUR Bln.). The sample includes all intervention days. In Panel B the dependent variable is the full-day % price change. Panel B also includes a significance (*Signif*) value for the test of the restriction that the slope parameter is equal in the two comparable regressions. This is a log-likelihood ratio test that is  $\chi^2$  distributed under the null of no difference (*d.f.* =  $p(p + 1)$  minus the number of free parameters, where  $p$  is the number of dependent variables). Heteroscedasticity and serial correlation robust t-statistics are reported in brackets. Parameter estimates that are statistically different from zero at the 10% level of significance or better are in bold.  $\bar{R}^2$  is the adjusted R-Squared statistic. The first day and the re-start of SMP is omitted from the sample in all cases and the outlier on 25<sup>th</sup> Nov 2011 is also dropped.

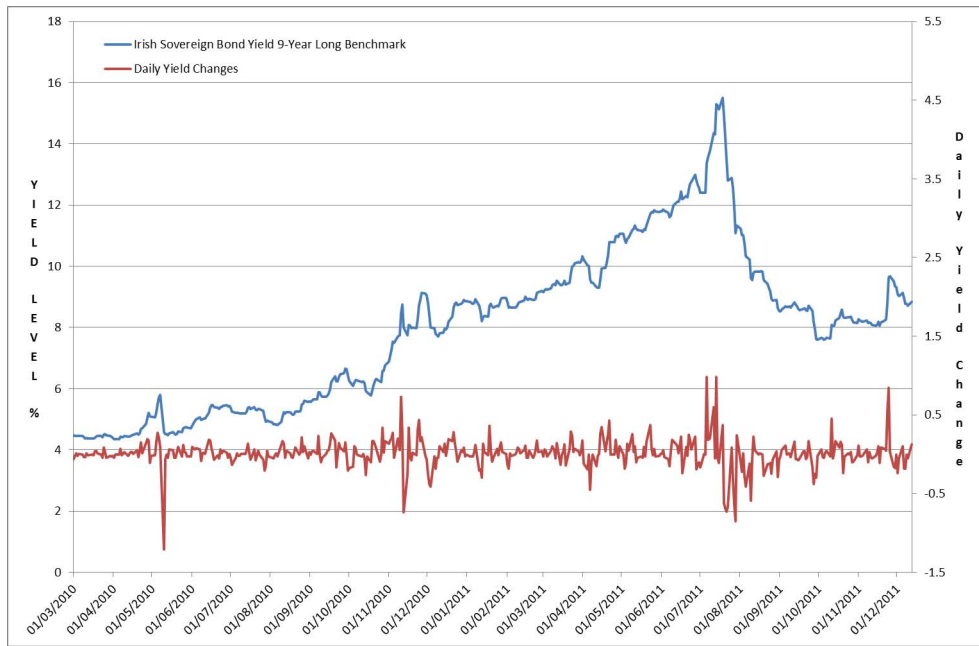


Figure 1: Yield and Daily Yield Changes Irish 9Y Bond.

Note: This figure displays how the Irish 9 year yield moved over the course of the SMP programme. The yield is plotted against the left axis while the daily changes are plotted against the right axis.



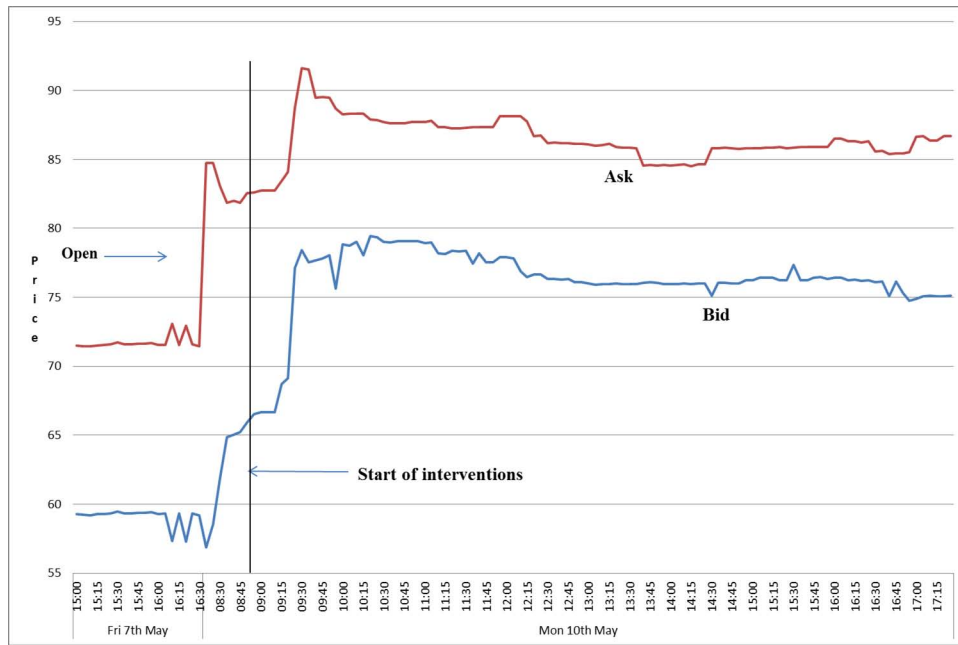


Figure 2: Average bid and ask quotes around announcement of SMP.

Note: The average bid and ask quotes for the six most frequently quoted Greek bonds is shown for the last hour and a half of trading on the Friday before SMP was announced and on the first day of SMP.

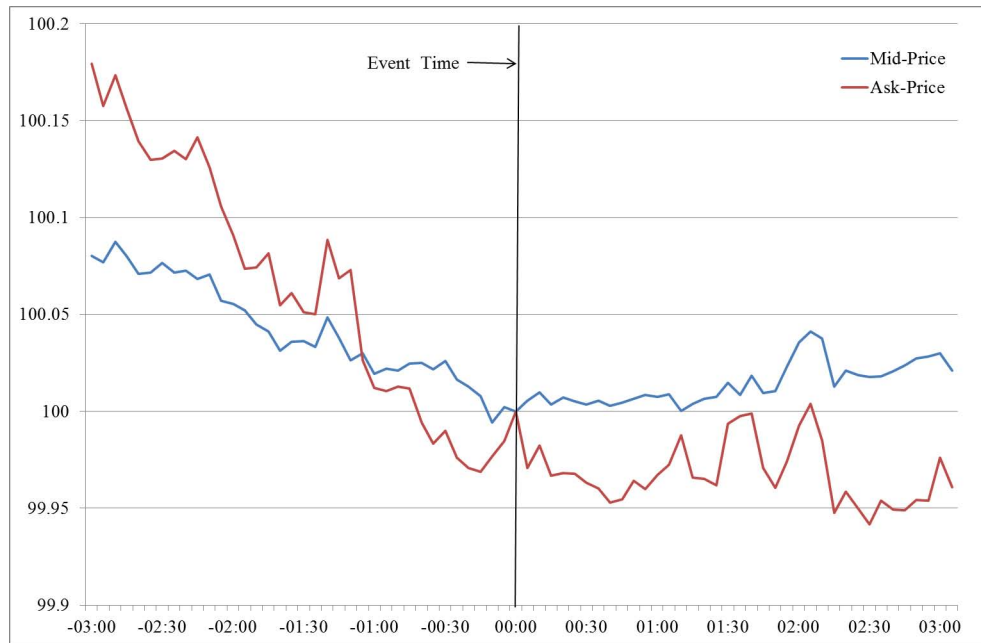


Figure 3: CAR for all SMP initial purchase events (May 2010-to-Dec 2011).

Note: Starting at 100 at the time of the first intervention on each SMP day the average % price changes in each five minute interval are used to generate the pre-intervention(post-intervention) index by discounting(compounding) respectively to obtain the index levels at the beginning of intervals before(after) the event. In general, this gives rise to a higher index value before intervention and stability after interventions. The ask-price displays a more pronounced decline than the mid-price in the pre-intervention period on average and this probably reflects the decline in the size of the bid-ask spread during the early part of the day.

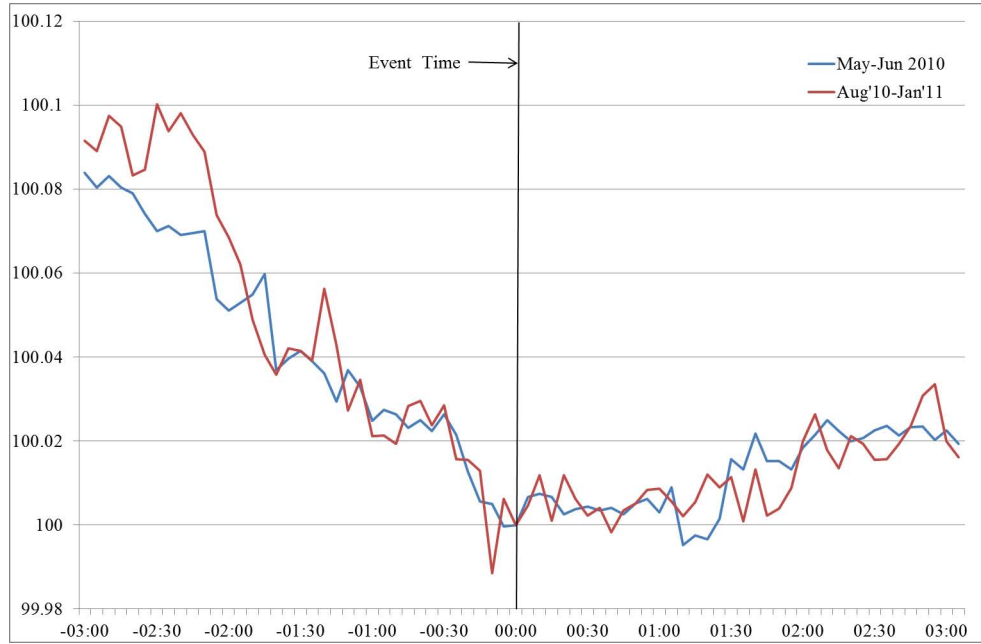


Figure 4: CAR for Intervention Days Pre- and Post-Dec 2010.

Note: SMP days are divided into two episodes to ascertain whether there was stability in the event effects. Starting at 100 at the time of the first intervention on each SMP day the average % price changes in each five minute interval are used to generate the pre-intervention(post-intervention) index by discounting(compounding) respectively to obtain the index levels at the beginning of intervals before(after) the event. In general, this gives rise to a higher value before intervention and stability after interventions. There is no significant difference between the two episodes.

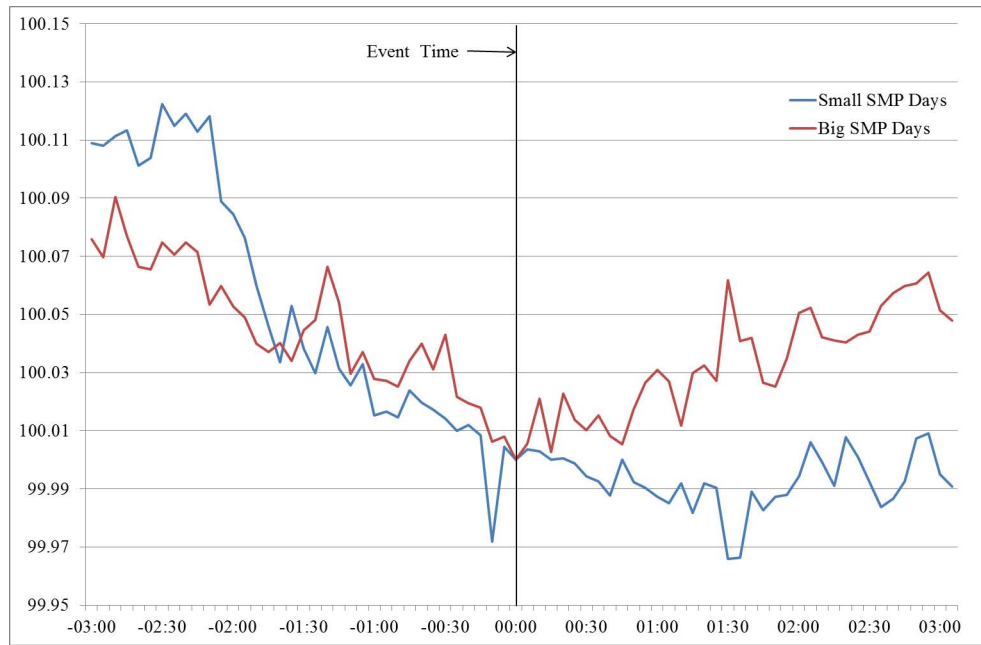


Figure 5: CAR for Big and Small Intervention Days.

Note: SMP days are divided into two roughly equal groups depending on their rank in terms of the amount of intervention. Starting at 100 at the time of the first intervention on each SMP day the average % price changes in each five minute interval are used to generate the pre-intervention(post-intervention) index by discounting(compounding) respectively to obtain the index levels at the beginning of intervals before(after) the event. In general, this gives rise to a higher value before intervention and stability after interventions. The "big" SMP days appear to have some reversal in the postintervention period on average and this is borne-out by statistical testing.

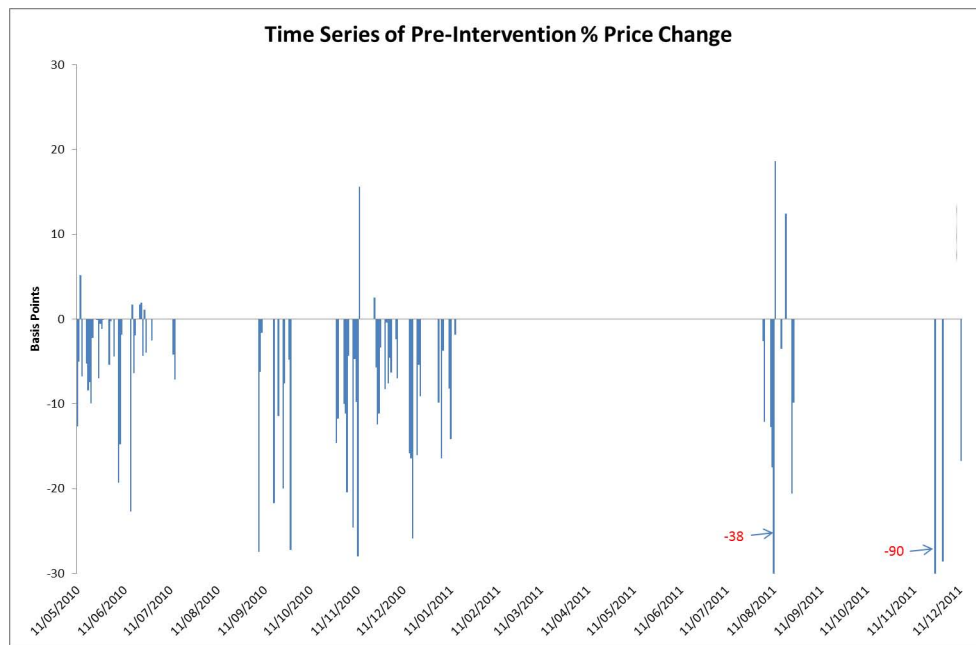


Figure 6: The time series of the pre-intervention basis-points decline in price for all intervention days.

Note: Where there are a number of bonds with interventions on the same day we report the bond with the maximum pre-intervention decline in price.



Figure 7: Cumulative pre- and post-SMP price effects.

Note: The pre- and post-SMP % price changes are separately compounded starting at 100. This shows clearly the difference in character of the intraday price movements that preceded SMP interventions and those that followed (only active SMP days are included). In general the pre-intervention price changes are negative while the post-intervention price changes are flat. The exception is the period just before Ireland sought bailout funding. The immediate pre-bailout period had negative post-intervention price changes. Once the bailout was requested there was a sustained improvement in post-intervention price changes until the 7<sup>th</sup> Dec when the stable pattern returns.